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Research Article

The Insecticidal Effects of *Pogostemon cablin* Against Coconut Leaf Beetle, *Brontispa longissima*

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Abstract

The coconut leaf beetle (*Brontispa longissima*) is a destructive pest in Malaysia, significantly impacting coconut plantations and leading to economic losses. While chemical pesticides are commonly used for control, their prolonged application raises concerns regarding human health risks, environmental impact, and the development of pesticide resistance. This study evaluates the insecticidal efficacy of Cypersect EC (Cypermethrin 5.5%), Neem oil (1.2% Azadirachtin), and natural biopesticides derived from *Pogostemon cablin* and *Clinacanthus nutans* leaf extracts against different developmental stages of *B. longissima* using a direct dipping method under laboratory conditions. Results indicate that Cypersect EC exhibited the highest mortality rates, significantly outperforming other treatments ($P < 0.05$), with increasing concentrations leading to higher mortality across all pesticide types. Among biopesticides, *P. cablin* extract demonstrated superior insecticidal activity compared to *C. nutans*, although neither achieved 100% mortality at the highest tested concentration. The study also found that *B. longissima* larvae were more susceptible to treatments than adult beetles, suggesting that early intervention could enhance control effectiveness. The mode of action analysis suggests that Cypersect EC disrupts neural function by inhibiting cholinesterase activity, whereas biopesticides likely exert toxicity through contact exposure and metabolic disruption. These findings underscore the potential of *P. cablin* as a sustainable alternative for *B. longissima* management, reducing dependence on synthetic chemicals while supporting environmentally friendly pest control strategies. Further research is recommended to optimize *P. cablin* formulations, assess its long-term field efficacy, and explore its integration into integrated pest management (IPM) programs for sustainable coconut cultivation.

Keywords

Pogostemon cablin, Biopesticide, Coconut Leaf Beetle, *Brontispa longissima*, Insecticidal Activity

1. Introduction

Pogostemon cablin, commonly known as patchouli, is an herbaceous plant belonging to the family Lamiaceae. It is native to tropical regions of Southeast Asia, including countries such as Indonesia, the Philippines, and Malaysia. Known for its distinct aroma, patchouli plays a significant role in various fields, particularly in the perfume industry and tradi-

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tional medicine [16]. Patchouli grows upright, reaching a height of 0.6 to 1 meter. Its dark green leaves are oval-shaped with a fine, hairy surface. The plant's flowers, which range in color from white to purple, appear in clusters during the summer season. Thriving in humid climates and nitrogen-rich soil, patchouli has been cultivated extensively for its economic and therapeutic value [18].

In traditional medicine, patchouli has been used for centuries to address various health issues, including anti-inflammatory properties, where extracts from patchouli leaves are used to reduce inflammation and pain. Its antiseptic effects make patchouli oil often applied to wounds and skin infections. Additionally, the sedative effects of patchouli's aroma are believed to have calming properties, helping to alleviate stress, anxiety, and sleep disorders [21]. It also has deodorizing properties, with patchouli being used in aromatherapy to eliminate unpleasant odors and improve mood. Beyond its health and cosmetic applications, *Pogostemon cablin* offers substantial economic potential to farmers and small-scale entrepreneurs in its producing regions. With the growing interest in natural and organic products, global demand for patchouli oil continues to rise. Overall, *Pogostemon cablin* is a highly valuable plant with diverse applications in traditional medicine and the perfume industry. Further exploration of its benefits and uses remains relevant and intriguing. One emerging area of interest is its potential use as a natural insecticide, particularly against *Brontispa longissima*, the coconut leaf beetle.

Patchouli oil, derived from the leaves of *Pogostemon cablin*, contains several active compounds with documented insecticidal properties. Key components include patchoulol, a primary constituent known for its antimicrobial and insecticidal activity, and eugenol, a compound with neurotoxic effects on pests [10]. The active compounds in patchouli oil exhibit insecticidal effects by disrupting the nervous system and metabolic processes of *Brontispa longissima*. This disruption ultimately leads to the death of the pest. Patchouli oil acts as a contact or fumigant insecticide, offering versatility in application methods.

The coconut leaf beetle, *Brontispa longissima* poses a significant threat to coconut plantations, with infestations leading to substantial yield losses. The pest, believed to originate from Papua New Guinea and Indonesia, spread to other Pacific islands and Australia by the late 1930s [22, 24]. In Malaysia, it was first recorded in 2005 [19, 5]. The larvae and adult beetles primarily feed on the young leaves of coconut trees, causing them to dry out and turn brown, thereby impacting the plant's health and productivity [9, 14, 17]. Severe infestations can result in significant damage to coconut crops, leading to considerable economic losses [11, 12].

Chemical pesticides are often the primary choice for controlling *B. longissima* due to their ease of application and immediate efficacy [7, 23]. However, the prolonged and uncontrolled use of chemical pesticides poses risks to ecosystems and increases pest resistance [2]. Thus, organic alternatives like biopesticides derived from plant extracts have been introduced to counterbalance the use of synthetic pesticides [8, 15]. Biopesticides are generally safer and have minimal side effects on humans and other organisms [13]. Therefore, biological control methods are seen as a viable alternative to evaluate and mitigate the impact of this invasive pest on coconut ecosystems and landscapes [20].

2. Materials and Methods

2.1. Experimental Insects

A laboratory population of *B. longissima* was established by collecting larvae and adult from infected palm trees in the MARDI Bagan Datuk, Perak, Batu Pahat and Pontian, Johor. Larvae and adult were reared on leaf cutting at 27 ± 1°C, 75 ± 5% RH. After adults emerged, they were placed in plastic container (6.2 cm height x 9.0 cm diameter) and supplied with leaf cutting and cotton wicks saturated with 8-10 % honey for feeding. Subsequently, eggs were transferred to a moist sterile leaf cutting within an unsealed test container (220 mm high x 120 mm diameter). Upon hatching, neonate larvae were individually transferred to test container (220-mm high x 120 mm diameter) containing leaf cutting and cotton wicks saturated with 8-10 % honey for feeding. Approximately 7 days later, laboratory-reared larvae were obtained for further analysis [5].

2.2. Laboratory Bioassays

B. longissima larvae of similar size during the feeding period were selected. Cypersect EC (Cypermethrin 5.5%) and Neem oil (1.2% b.a: Neemix® - Azadirachtin) were used as insecticides. While *Pogostemon cablin* (locally known as Nilam) and *Clinacanthus nutans* (locally known as Belalai gajah) plants were used as biopesticides. The extraction of the *P. cablin* according to Smith et al. (2022) was performed using hexane with some modification. Sample of *P. cablin* leaves was obtained from MARDI Kuala Linggi, Melaka. The leaves were harvested, washed with clean water, drained and left to dry at room temperature in the Entomological laboratory, Industrial Crops Research Centre, MARDI Serdang. Then, the air-dried leaves were subjected to oven drying at 45-50°C to achieve final moisture content of 5-10%, followed by grinding into fine homogeneous powder (with mesh 720 µm) using a grinder (Wiley). The powder was extracted using hexane with a soxhlet (Velp) tool. Pesticides and biopesticides used in this study were dissolved in one liter of distilled water to obtain a 2.5% solution of active substances as stock solutions [1]. Each stock solution was then used to produce a series of concentrations required in the experiment by diluting it in distilled water.

2.3. Direct Dipping Method

Direct dipping was carried out in accordance to Rahman and Talukder (2006) with some modifications. Ten *B. longissima* larvae age 3-4 days old were randomly selected from the former preservation and placed in a plastic container (6.2 cm height x 9.0 cm diameter) before being immersed in an insecticidal solution of 1.0, 0.5, 0.25 as well as 0.1% active ingredients and distilled water (as control) for 3 seconds. The larvae were then left to dry for two hours before placed in a 220-mm high x 120 mm diameter 0.1 test container. A few strands of young coconut leaves were included as a source of food for *B. longissima*. Each treatment was repeated 4 times and the number of dead larvae were recorded at 24, 48 and 72 hours after treatment. Larvae were considered dead if they do not respond when touched with a soft color brush. The same experiments were also done on the male and female adult brontispa against the same concentration of insecticide (1.0, 0.5, 0.25 and 0.1% active substance).

3. Results and Discussion

Assessment Mean of Mortality
Direct Dipping Method

Three-way ANOVA test showed a significant mean percentage of *B. longissima* larvae mortality on the concentration factor (F = 152.72; df = 3,144; P <0.05) and pesticides factor (F = 71.8; df = 3,144; P <0.05). On the other hand, the stages factor (F = 1.27; df = 2,144; P> 0.05) did not show a significant difference to the percentage mortality of *B. longissima* (Table 1). Using a direct dipping method, the percentage of beetle mortality increased with the increased concentration of pesticides solutions (Figure 1). This indicated that both chemical pesticides and natural biopesticides can kill more pests at higher concentrations [4, 6]. Similar results were also obtained by Osman (2010) in his study on the *Leptinotars decemlineata* beetle. Hemingway et al. (2002) also proposed that, increasing the concentrations or dose of pesticides caused higher mortality of the tested insect. Active ingredients play a very important role in the assay of pesticides such as organophosphates in which these pesticides invade the nervous system of the insect by causing nerve pulse and reducing the ability of the nervous system to function normally and eventually lead to the mortality of insects [3]. Meanwhile, S. Rashid et al. (2012) stated that high concentration of dose also improves kinetic effect on the insect biological systems, causing mortality in a shorter period.

Table 1. *Mean percentage of B. longissima mortality for dosage concentration, beetle stage and type of pesticide and interaction between the three factors by direct dipping method.*

Factor	Df	SE	F value	P value
Concentration	3	45418.9	152.72	< 0.05
Stage	2	41.0	1.27	> 0.05
Pesticides	3	10521.9	71.8	< 0.05
Concentration x Stage	6	197.5	1.36	> 0.05
Concentration x Pesticides	9	2576.0	6.85	< 0.05
Stage x Pesticides	6	107.0	1.42	> 0.05
Concentration x Stage x Pesticides	18	215.8	1.65	> 0.05
Error	144	691.5		

The results also revealed that there was an interaction between the concentration factor and the type of pesticides (F = 6.85; df = 9,144; P <0.05) which showed a significant difference to the percentage of mortality of *B. longissima.* However, there was no interaction between concentration factor with stage (F = 1.36; df = 6,144; P> 0.05) and pesticides factor with stage (F = 1.42; df = 6,144; P> 0.05) similarly for concentration factor, pesticides and stage which did not show significant interaction (F = 1.65; df = 18,144; P> 0.05) to mean percentage of mortality of *B. longissima* (Table 1). It was also found that among the four types of pesticides used, Cypersect EC (Cypermethrin 5.5%) recorded the mean percentage of *B. longissima* mortality at all concentrations compared to other treatments (Figure 1). This is in accordance with Choo-Toh and Gumbek (1999). They found that a cypermethrin was very effective in controlling coconut leaf-beetle such as *Plesispa reichei* and *Promecotheca nucifera*. According to Ahmed (2006), cypermethrin are among the main active ingredients that are widely used as insecticides apart from the use of other active substances such as imidacloprid, fipronil and bifentrin. Cypermethrin acts by interfering cholinesterase enzyme (ChE), which is the enzyme required in the nervous system of insects. The cholinesterase enzyme serves as the mediator of the impulse sender from one nerve to another. The inhibition of this enzyme causes the impulse to be transmitted continuously to the muscles and will cause accumulation of acetylcholine (ACh) on the nerve. As a result, these organisms that experience pesticide will having muscle cramps, the muscles will tremble and eventually lead to death [25].

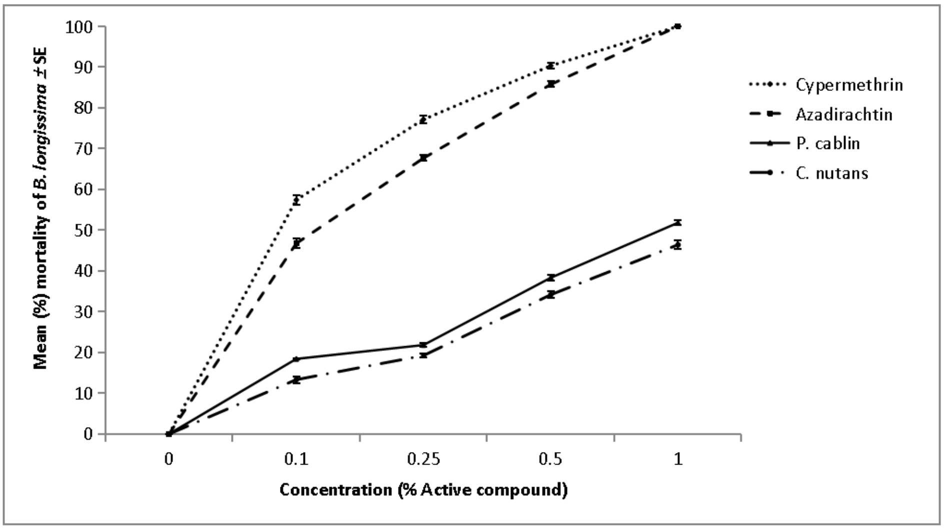

Figure 1. *Mean percentage mortality of B. longissima by different pesticides and biopesticides at different concentrations using direct dipping method.*

Generally, the mortality of *B. longissima* larvae increased as the concentration of pesticides increased. Mean percentage of mortality was significantly higher than *P. cablin* and *C. nutan* when the larvae were treated with chemical pesticides at all concentrations (Figure 1). At concentrations 0.1 to 0.5 (% of active ingredient), the effect of Cypermethrin pesticides was stronger and more significant on the mortality of *B. longissima* larvae compared to Azadirachtin (Neemix®). However, both pesticides killed all the larvae (100% mortality) when *B. longissima* was treated with 1.0 % of active ingredient. For biopesticide, *P. cablin* leaf extract was more effective in killing *B. longissima* larvae based on higher percentage of larvae mortality at all concentrations compared to *C. nutans* leaf extract. However, in contrast to chemical pesticides, both biopesticides were unable to record 100% mortality at concentrations of 1.0 (% of active ingredients).

The total mortality percentage recorded at all three stages of *B. longissima* increased with higher pesticide active ingredient concentrations (%). The 1% pesticide active ingredient concentration recorded the highest significant ($P<0.05$) mortality percentage (67.5 ± 5.3%) towards *B. longissima* larval stages compared to the other stages. Meanwhile, the lowest mortality percentage (4.7 ± 1.1%) was recorded at the 0.125% pesticide active ingredient concentration at the adult female stage of *B. longissima* (Figure 2).

The findings of this study demonstrate the insecticidal potential of *Pogostemon cablin* against *Brontispa longissima*, highlighting its role as an alternative to synthetic pesticides. While Cypersect EC (Cypermethrin 5.5%) exhibited the highest mortality rates, the results also suggest that *P. cablin* extract holds promise as a biopesticide, providing a more environmentally friendly approach to coconut beetle management. Previous research on biopesticides has demonstrated the efficacy of plant-derived compounds against agricultural pests. Chaojun et al. (2011) found that botanical extracts effectively controlled *B. longissima*, supporting our findings that plant-based insecticides can significantly impact pest populations. Similarly, Kang et al. (2019) [10] reported that patchouli oil (*P. cablin* extract) exhibited strong insecticidal properties against various agricultural pests, consistent with the present study's results. The mode of action of *P. cablin* is believed to be due to its active compounds, such as patchoulol and eugenol, which disrupt the nervous system and metabolic pathways of insects. This aligns with Osman (2010) [15], who emphasized the role of botanical insecticides in interfering with insect physiology while reducing environmental risks. Unlike synthetic pesticides, which often lead to pesticide resistance (Bailey et al., 2010), biopesticides present a sustainable alternative with a lower likelihood of resistance development.

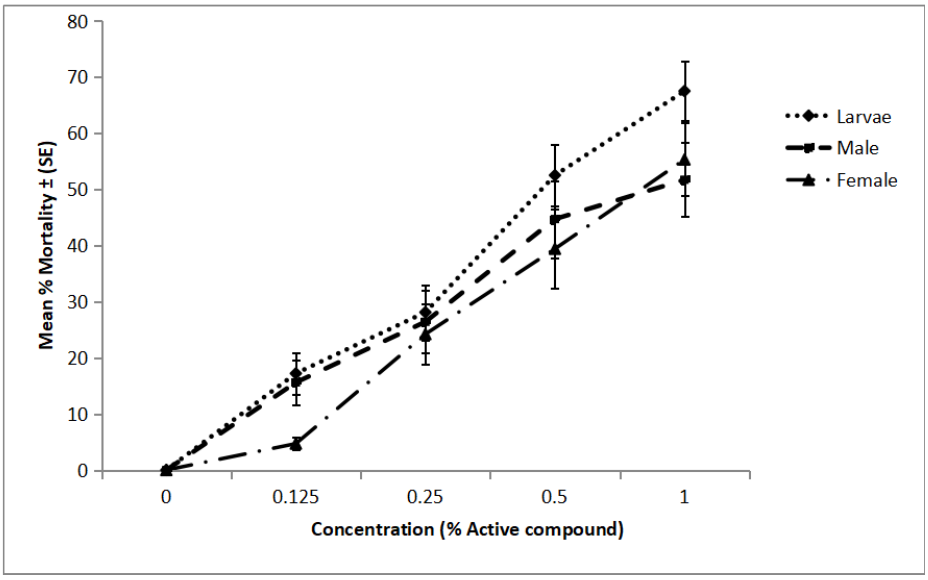

Figure 2. *Mean percentage mortality of B. longissima at different pesticide concentrations and insect stages using direct dipping method.*

The widespread use of synthetic pesticides like cypermethrin has raised concerns over environmental contamination, non-target organism toxicity, and human health risks (Miao, 2005). In contrast, botanical pesticides such as *P. cablin* offer a safer alternative with biodegradable properties and minimal toxic residues. The results indicate that *P. cablin* extract could be incorporated into Integrated Pest Management (IPM) programs, reducing reliance on synthetic insecticides. Lu et al. (2008) emphasized the importance of integrating botanical insecticides with biological control measures to achieve long-term pest suppression. Further research should explore synergistic effects between *P. cablin* and natural predators of *B. longissima*, such as parasitoid wasps (Rethinam & Singh, 2007).

4. Conclusion

Pogostemon cablin shows significant potential as a natural insecticide against *Brontispa longissim*a. Its use not only provides an environmentally friendly solution to pest management but also supports sustainable agricultural practices. However, addressing challenges related to production costs and raw material supply will be essential for broader adoption. Further research is needed to maximize the benefits of this promising plant-based insecticide.

Abbreviations

MARDI	Malaysian Agricultural Research and Development Institute

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Author Contributions

Wan Khairul Anuar Wan Ali: Data curation, Methodology, Writing – original draft, Writing – review & editing

Nor Ahya Mahadi: Resources

Badrol Hisham Ibrahim: Resources

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Conflicts of Interest

The authors declare no conflicts of interest.

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